Materials Engineering Branch

TIP*

No. 066 Real Time Monitoring of Outgassing from Off-the-shelf Hardware

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In order to reduce the potential for outgassing contamination from organic materials included in flight hardware, the ideal (and recommended) procedure is to select, before the fact, only those materials that have acceptable vacuum outgassing. The material screening criteria, per ASTM E-595, are a TML = 1.00% and a CVCM = 0.10%. However, there are occasions when this is not possible or feasible and it becomes necessary to purchase commercial off-the-shelf (COTS) hardware that may include unidentifiable materials, materials whose outgassing properties are unknown or materials with unacceptable outgassing properties. In such cases, the threat of contamination due to outgassing becomes a real concern to the overall success of a mission, especially one which includes sensitive optics, critical thermal control surfaces, solar arrays, cryogenic coolers, etc.

To determine the outgassing profile of such hardware prior to integrating it into the flight hardware, a technique which has been successfully used on numerous occasions is to monitor the real-time outgassing by placing it in a thermal vacuum chamber along with a quartz crystal microbalance (QCM), and a cold-finger strategically positioned so that they are in direct line-of-sight of the hardware in question. The QCM is a real-time monitoring device that incorporates a crystal whose frequency continuously changes as condensable material deposits on its surface and is maintained at a predefined temperature. The cold-finger is a temperature-controlled device used to collect condensable materials for chemical analysis.

Typically, the thermal vacuum chamber is evacuated to a pressure of 10^{-6} torr, and the hardware under test is raised to the highest safe temperature and maintained there until the QCM frequency rate of change that is monitored continually on a suitable recorder reaches an acceptable level as dictated by the project. When that occurs, it is assumed that the hardware has been sufficiently baked out. To substantiate this, the bake out is continued for an additional 8 hours during which time the cold-finger is activated, i.e., lowered to liquid nitrogen temperature, to allow it to collect condensable material that might still be coming off the hardware. This

provides a means for determining the amount and signature of outgassing products as well as the hardware cleanliness.

If, at the end of the final 8-hour bake out period over which the cold-finger is activated, the total weighed amount of condensable material collected by the cold-finger is less than 1-2 mg, the hardware is considered acceptable for space flight. However, other factors such as the cleanliness level, hardware contamination sensitivity and the type of outgassing species identified by chemical analyses must also be taken into account. Thus, a mass of 1-2 mg may be too lenient in some cases and too strict in others.

On the other hand, if the condensable amount exceeds 1-2 mg, or the maximum acceptable amount, a recommendation might include removal of the materials responsible for the high outgassing as determined by chemical analysis of the condensables and/or additional vacuum bake out for a specified time with cold-finger included to collect condensable materials for chemical analysis. The latter bake out procedure should be repeated until the total collected condensables reaches an acceptable level; i.e., 1-2 mg.

NOTES:

1. Prior to placing the hardware being baked out in the thermal vacuum chamber, its external surfaces must be solvent cleaned using only approved materials (solvents and Soxhlet-extracted cleaning cloths), and an approved procedure.

2. The cold-finger acceptable condensable amount of 5 mgs is arbitrary and relates only to the thermal vacuum test facilities typically used at the GSFC. The acceptable amount of cold-finger condensables is highly dependent upon the chamber background that must be determined prior to hardware bake out.

3. The QCM frequency rate change usually considered acceptable at GSFC, is 300 counts per hour, or less, as determined over many years of flight hardware testing.